Protons, Neutrons, and Electrons Practice Worksheet

Fill in the blanks in the following worksheet. Please keep in mind that the isotope represented by each space may NOT be the most common isotope or the one closest in atomic mass to the value on the periodic table.

Atomic symbol	Atomic number	Protons	Neutrons	Electrons	Mass Number
B	5	5	6	5	11
Na	11	11	13	11	24
Ga	31	31	37	31	68
Y	39	39	50	39	89
Cu	29	29	35	29	64
Tc	43	43	57	43	100
Pb	82	82	125	82	207
Yb	70	70	102	70	172
Ac	89	89	136	89	225
Mo	42	42	53	42	95
Tl	81	81	125	81	206
Fm	100	100	159	100	259
No	102	102	159	102	261
Yb	70	70	102	70	172
Sg	106	106	159	106	265

1. Determine the number of protons, neutrons, and electrons present in each of the following atoms.

2.

	p^+	n^0	e^-
a) $^{28}_{14}Si$	14	14	14
b) $^{197}_{79}Au$	79	118	79
c) $^{40}_{18}Ar$	18	22	18
d) Cu-64	29	35	29
e) K-39	19	20	19
e) Cs-133	55	78	55

3. Represent the following isotopes in two different ways.

a) $30p^+, 30e^-, 38n^0$

Zn-68 $^{68}_{30}Zn$

b) $53p^+, 53e^-, 68n^0$

I-121 $^{121}_{53}I$

4. 3. Identify atoms that are isotopes in each of the following sets of four atoms.

a) $^{80}_{35}X$, $^{82}_{35}X$, $^{81}_{36}X$ → isotopes of Bromine

b) $^{19}_{9}X$, $^{19}_{10}X$, $^{17}_{9}X$, $^{20}_{8}X$ → isotopes of Fluorine

c) $^{23}_{11}X$, $^{24}_{11}X$, $^{25}_{11}X$ → isotopes of sodium

d) $^{70}_{31}X$, $^{70}_{32}X$, $^{70}_{33}X$, $^{70}_{34}X$ → no isotopes

Atomic Mass Problems

1. Calculate the weight of silicon using the following data for the percent natural abundance and mass of each isotope:
   92.23% ^{28}Si (27.9769 amu); 4.67% ^{29}Si (28.9765); 3.10% ^{30}Si (29.9738 amu).

   27.9769 x 0.9223 = 25.80309487
   28.9765 x 0.0467 = 1.35320255
   29.9738 x 0.0310 = +0.9291878

   → 28.09 amu

2. Thallium has two stable isotopes, ^{203}Tl and ^{205}Tl. Knowing that the atomic weight of thallium is 204.4, which isotope is the more abundant of the two?

   203 50/50 205 — 204

   If the isotopes were present in equal amounts, the atomic mass of Thalium would be 204. Because the actual mass is greater than 204, the mass is shifted toward the more abundant isotope Tl-205.

3. Verify that the atomic mass of magnesium is 24.31, given the following:

^{24}Mg= 23.985042amu, 78.99%	^{25}Mg= 24.985837 amu, 10.00%	^{26}Mg= 25.982593, 11.01%

   23.985042 x 0.7899 = 18.94578468
   24.985837 x 0.1000 = 2.4985837
   25.982593 x 0.1101 = + 2.860683459

   24.31 amu

4. Copper exists as two isotopes: ^{63}Cu (62.9298 amu) and ^{65}Cu (64.9278 amu). — This could be a bonus, but not standard test question.
   What are the percent abundances of the isotopes?

   Abundance of Cu-63 = X
   " " Cu-65 = 1-X

   From PT

   62.9298 X + 64.9278 (1-X) = 63.546

   62.9298 X + 64.9278 − 64.9278 X = 63.5460

   −1.9980X = −1.3818

   100 × X = 69.1592 %

   100 − X = 30.8408 %

Transmutation

Name: ______________

Transmutation is the process of converting one element into another (using bombardment with high energy particles). The **target nucleus** is the isotope which is bombarded, the **projectile** is the particle fired at the nucleus, the **product** is the new nucleus produced by the reaction, and the **ejected particle** is the light nucleus or particle emitted in the reaction. This bombardment takes place in a particle accelerator (cyclotron, synchrotron, linac, etc.). Many of the radioactive products of nuclear bombardment are useful in medicine and industry as tracers, etc..

Part 1: Fill in the blank in each transmutation reaction with the correct particle, and label each particle as the target, projectile, product, and ejected particle.

1. $^{14}_{7}N$ + $^{4}_{2}He$ --------> $^{1}_{1}H$ + $^{17}_{8}O$

2. $^{4}_{2}He$ + $^{27}_{13}Al$ -------> $^{30}_{15}P$ + $^{1}_{0}n$

3. $^{246}_{96}Cm$ + $^{12}_{6}C$ --------> $^{254}_{102}No$ + $4\,^{1}_{0}n$ (there are 4 neutrons)

4. $^{59}_{27}Co$ + $^{1}_{0}n$ ---------> $^{60}_{27}Co$

5. $^{97}_{42}Mo$ + $^{1}_{1}H$ ------------> $^{97}_{43}Tc$ + $^{1}_{0}n$

6. $^{209}_{83}Bi$ + $^{4}_{2}He$ ----------> $^{1}_{0}n$ + $^{212}_{85}At$

7. ^{1}P + $^{239}_{92}U$ ----------> $^{238}_{93}Np$ + $2\,^{1}_{0}n$ (2 neutrons)

8. $^{98}_{42}Mo$ + $^{1}_{0}n$ ---------> $^{0}_{-1}e$ + $^{99}_{43}Tc$

9. $^{1}_{0}n$ + $^{40}_{20}Ca$ ---------> $^{40}_{19}K$ + $^{1}_{1}H$

10. $^{2}_{1}H$ + $^{3}_{2}He$ ----------> $^{4}_{2}He$ + $^{1}_{1}H$

Part 2: Rewrite the following reactions in symbol form:

11) A neutron hits a uranium-235 atom, splitting it into a barium-140 atom, a krypton-93 atom and 3 neutrons.

$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{140}_{56}Ba + ^{93}_{36}Kr + 3\,^{1}_{0}n$

12) A zirconium-95 atom undergoes beta decay to become stable.

$^{95}_{40}Zr \rightarrow ^{0}_{-1}\beta + ^{95}_{41}Nb$

13) A cobalt-59 nucleus is bombarded by a neutron to roduce cobalt-60.

$^{59}_{27}Co + ^{1}_{0}n \rightarrow ^{60}_{27}Co$

14) An iron-58 is hit by a bismuth-209 nucleus to form meitnurium-266 and a neutron.

$^{58}_{26}Fe + ^{209}_{83}Bi \rightarrow ^{266}_{109}Mt + ^{1}_{0}n$

15) A molybdenum-96 atom is hit by deutrium (hydrogen-2) to form technetium-97 and a neutron.

$^{96}_{42}Mo + ^{2}_{1}H \rightarrow ^{97}_{43}Tc + ^{1}_{0}n$

Part 3: Determine the product nucleus of the following reactions:

16) A curium-246 nucleus is hit by a carbon-12 atom to produce what product nucleus and 4 neutrons?

$^{246}_{96}Cm + ^{12}_{6}C \rightarrow 4\,^{1}_{0}n + \boxed{^{254}_{102}No}$

17) A lead-218 atom decomposes by alpha decay to produce what new nucleus?

$^{218}_{82}Pb \rightarrow ^{4}_{2}He + \boxed{^{214}_{80}Hg}$

18) A neutron is fired at a uranium-235 atom, where the atom splits apart into what product atom along with zirconium-97 and 2 neutrons?

$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{97}_{40}Zr + 2\,^{1}_{0}n + \boxed{^{137}_{52}Te}$

$\frac{1}{2}$ $\frac{1}{4}$ $\frac{1}{8}$ $\frac{1}{16}$ $\frac{1}{32}$ $\frac{1}{64}$ $\frac{1}{128}$ $\frac{1}{256}$ $\frac{1}{512}$ $\frac{1}{1024}$ $\frac{1}{2048}$

Half-life Practice Worksheet

1. Sodium-24 has a half-life of 15 hours. How much sodium-24 will remain in an 18.0 g sample after 60 hours?

   initial = 18g
   final = x
   n = 4
   TE = 60h
   t½ = 15h

   $\frac{final}{initial} = \left(\frac{1}{2}\right)^n$ $\frac{x}{18} = \frac{1}{16}$ **x = 1.13g**

2. After 42 days a 2.0 g sample of phosphorus-32 contains only 0.25 g of the isotope. What is the half-life of phosphorus-32?

   initial = 2.0g
   final = 0.25g
   n =
   TE = 42d
   t½ =

   $\frac{0.25}{2.0} = \frac{1}{8} = \left(\frac{1}{2}\right)^n$ n = 3 TE/t½ = 3

   $\frac{TE}{3}$ = t½ = 14d

3. Polonium-214 has a relatively short half-life of 164 seconds. How many seconds would it take for 8.0 g of this isotope to decay to 0.25 g?

   initial = 8.0g
   final = 0.25g
   n =
   TE =
   t½ = 164s

   $\frac{0.25g}{8g} = \frac{1}{32} = \left(\frac{1}{2}\right)^n$ n = 5 TE/t½ = n

   TE = n·t½
   = 5×164
   820 sec

4. How many days does it take for 16 g of palladium-103 to decay to 1.0 g? The half-life of palladium-103 is 17 days.

   initial = 16g
   final = 1g
   n = 4
   TE =
   t½ = 17d.

   $\frac{1}{16} = \left(\frac{1}{2}\right)^n$ n = 4

   TE = n·t½
   4 × 17d = **68 d**

5. By approximately what factor would the mass of a sample of copper-66 decrease in 51 minutes? The half-life of copper-66 is 5.10 minutes.

   initial =
   final =
   n =
   TE = 51 min
   t½ = 5.10 min

   51/5.10 = n = 10 $\left(\frac{1}{2}\right)^{10}$ = **$\frac{1}{1024}$**

6. In 5.49 seconds, 1.20 g of argon-35 decay to leave only 0.15 g. What is the half-life of argon-35?

   initial = 1.20g
   final = 0.15g
   n =
   TE = 5.49s
   t½ =

   $\frac{0.15}{1.20} = \left(\frac{1}{2}\right)^n$ n = 8

   $\frac{TE}{n}$ = t½ = $\frac{5.49}{8}$ = **0.686s**

HALF-LIFE PROBLEMS

Name________________________________ Block _______

1. An isotope of cesium (cesium-137) has a half-life of 30 years. If 1.0 g of cesium-137 disintegrates over a period of 90 years, how many g of cesium-137 would remain?

initial = 1g
final =
n = 3
TE = 90
$t_{1/2}$ = 30 y

$\frac{x}{1} = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$ $\boxed{x = 0.13\,g}$

2. Actinium-226 has a half-life of 29 hours. If 100 mg of actinium-226 disintegrates over a period of 58 hours, how many mg of actinium-226 will remain?

initial = 100mg
final = x
n = 2
TE = 58
$t_{1/2}$ = 29 hr.

$\frac{x}{100\,mg} = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$ $\boxed{x = 25\,mg}$

3. Sodium-25 was to be used in an experiment, but it took 3.0 minutes to get the sodium from the reactor to the laboratory. If 5.0 mg of sodium-25 was removed from the reactor, how many mg of sodium-25 were placed in the reaction vessel 3.0 minutes later if the half-life of sodium-25 is 60 seconds? → in the lab.

reactor → lab 3min

initial = 5.0mg
final =
n = 3
TE = 3min
$t_{1/2}$ = 60 s.

$\frac{x}{5.0\,mg} = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$ $\boxed{x = 0.63\,mg}$

4. The half-life of isotope X is 2.0 years. How many years would it take for a 4.0 mg sample of X to decay and have only 0.50 mg of it remain?

initial = 4.0 mg
final = 0.5 mg
n = 3
TE =
$t_{1/2}$ = 2.0 yr

$\frac{0.5}{4.0} = \frac{1}{8} = \left(\frac{1}{2}\right)^n$ n = 3 $3 \times 2.0 = \boxed{6\,yrs}$

5. Selenium-83 has a half-life of 25.0 minutes. How many minutes would it take for a 10.0 mg sample to decay and have only 1.25 mg of it remain?

initial = 10mg
final = 1.25mg
n =
TE =
$t_{1/2}$ = 25.0min

$\frac{1.25}{10} = \left(\frac{1}{2}\right)^n = \frac{1}{8}$ n = 3 $3 \times 25\,min = \boxed{75\,min}$

6. (A) The half-life of Po-218 is three minutes. How much of a 2.0 gram sample remains after 15 minutes? (B) Suppose you wanted to buy some of this isotope, and it required half an hour for it reach you. How much should you order if you need to use 0.10 gram of this material?

A. initial =
final =
n = 5
TE = 15min
$t_{1/2}$ = 3 min

A. $\frac{x}{2} = \left(\frac{1}{2}\right)^5$ $\frac{x}{2} = \frac{1}{32}$ $\boxed{x = 0.063\,g}$

B. $\frac{0.10}{x} = \left(\frac{1}{2}\right)^n$ TE = 90min, $t_{1/2}$ = 3 min, n = 30 $\boxed{x = 1.1 \times 10^9\,g}$